

DRONE IMAGERY: DATA PROCESSING TOOLS



Point cloud
LAS file



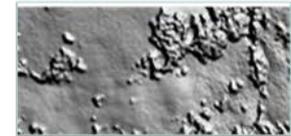
Orthomosaic
GeoTiff



Contour lines
Shapefile



DSM (surface model)
GeoTiff / LAS file



I. First overview of tools.

Data processing tools can be divided between open source and commercial software as well as online versus desktop solutions.

I.1. Open source projects.

- OpenDroneMap “specifically designed for UAVs, providing a wide range of orthophoto, point cloud, and surface model construction tools with a command line interface” (P. Johnson, B. Ricker, S. Harrison, 2017).
- Map Mill, an online platform to upload, sort and share imagery. It is completed by MapKnitter to create maps from those aerial imageries.
- MicMac is the open source program developed by the IGN (French National Geographic Institute).

I.2. Commercial solutions.

Commercial solutions cover a large variety of services from cloud-based to fully-featured GIS Softwares. Agisoft Photoscan, PhotoModeller, SFMToolkit, Photosynth, Bundler, PMVS2, PIX4D, VisualSfM, 123DCatch, Drone2Map for ArcGIS, SURE, CloudCompare, Maps Made Easy, DroneMapper, DroneDeploy are the main tools mentioned in literature.

I.3. A first comparison.

Table 1: Image processing services and softwares (P.Johnson, B.Ricker, S.Harison, 2017)

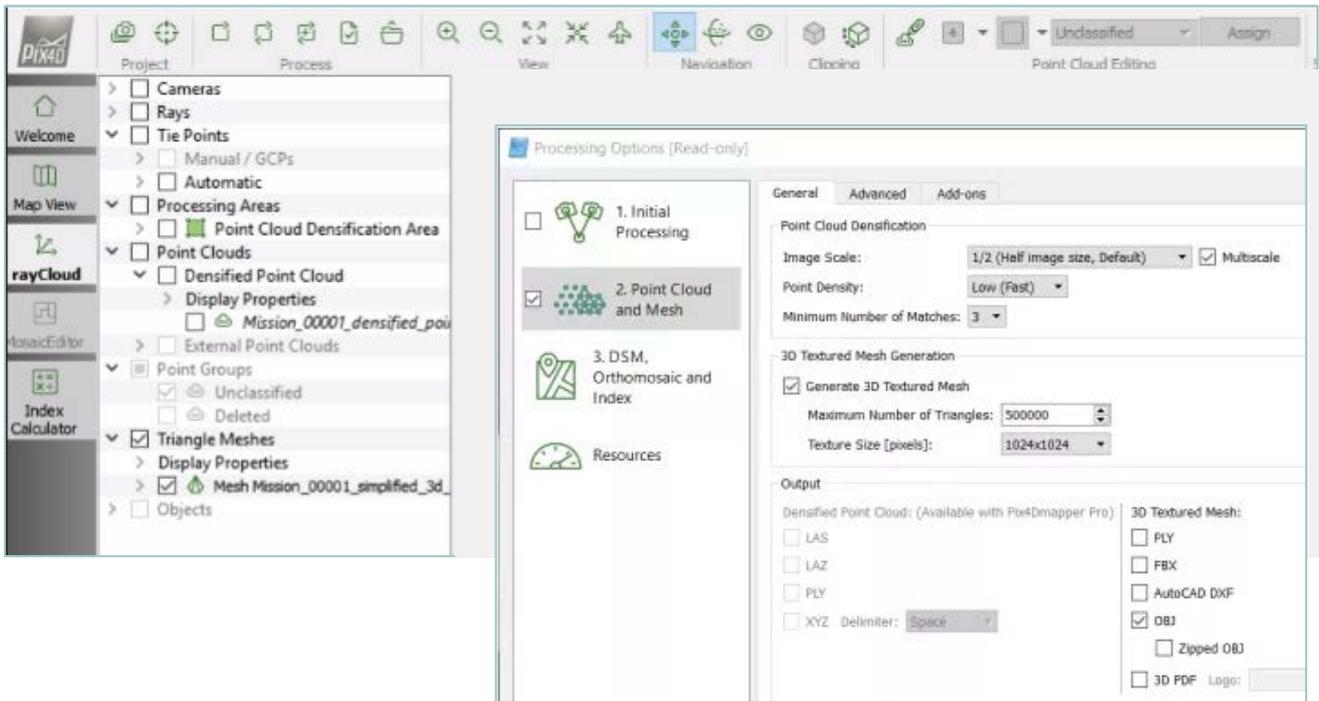
Name	Description	Desktop or Web service & Actions Facilitated	Licensing & Payment Model
OpenDroneMap http://opendronemap.github.io/odm	Open source toolkit for processing civilian drone imagery. The long-term aim of the tool is to optionally push resulting data to online repositories.	Desktop, Stitching	Licensing not specified; users assumed to own copyright. Free of charge
MapMill https://mapmill.org/	Public Lab tool for uploading and sorting balloon and kite imagery.	Web service, Sorting for subsequent stitching, Sharing	Creative Commons. Free of charge
MapKnitter https://mapknitter.org	Allows users to make maps from aerial photos.	Web service, Stitching	Creative Commons. Free of charge
Drone2Map for ArcGIS http://www.esri.com/products/drone2map	Convert raw still imagery from drones into 2D and 3D orthorectified products and perform some analysis.	Desktop, Stitching, analysis	Licensing not specified; users assumed to own copyright. Two payment requirements: 1. Paid ArcGIS Online License 2. Purchase additional Drone2Map software package (price not available).
Pix4D https://pix4d.com/	Software automatically converts imagery into georeferenced 2D maps and 3D models.	Desktop, Stitching, analysis	Users own their content. Four purchasing levels ranging from \$350 USD for monthly rental to \$8,700 for full purchase to own the software with 1 free upgrade and additional upgrades for \$870/year.
Maps Made Easy http://www.mapsmadeeasy.com	Make orthophoto maps and 3D models.	Web Service, Stitching	Users own their content. Pay per use.
DroneMapper https://dronemapper.com/	Generate geo-referenced Orthomosaics and Digital Elevation Models.	Web Service, Stitching	Processing user imagery grants DroneMapper rights to the final product. Minimum charge of \$250-\$500 USD for opening an account.
DroneDeploy http://www.dronedeploy.com/	Cloud-based app for building aerial maps and models using drone imagery	Web Service, Stitching	Users own their content. Four types of subscription plans ranging from free limited use to \$499/month for full suite of features.

II. Workflow comparison between AgiSoft, Drone2Map and Pix4D.

The choice was made to focus on those three softwares for the following reasons: CartONG already used Pix4D for a mission with partner, Drone2Map is the ESRI solution and we daily work with their other products for one of our main partner and finally AgiSoft was a literature recommendation we wanted to try.

II.1. Pix4D workflow.

Pix4D is a very user-friendly commercial software.



Strong points:

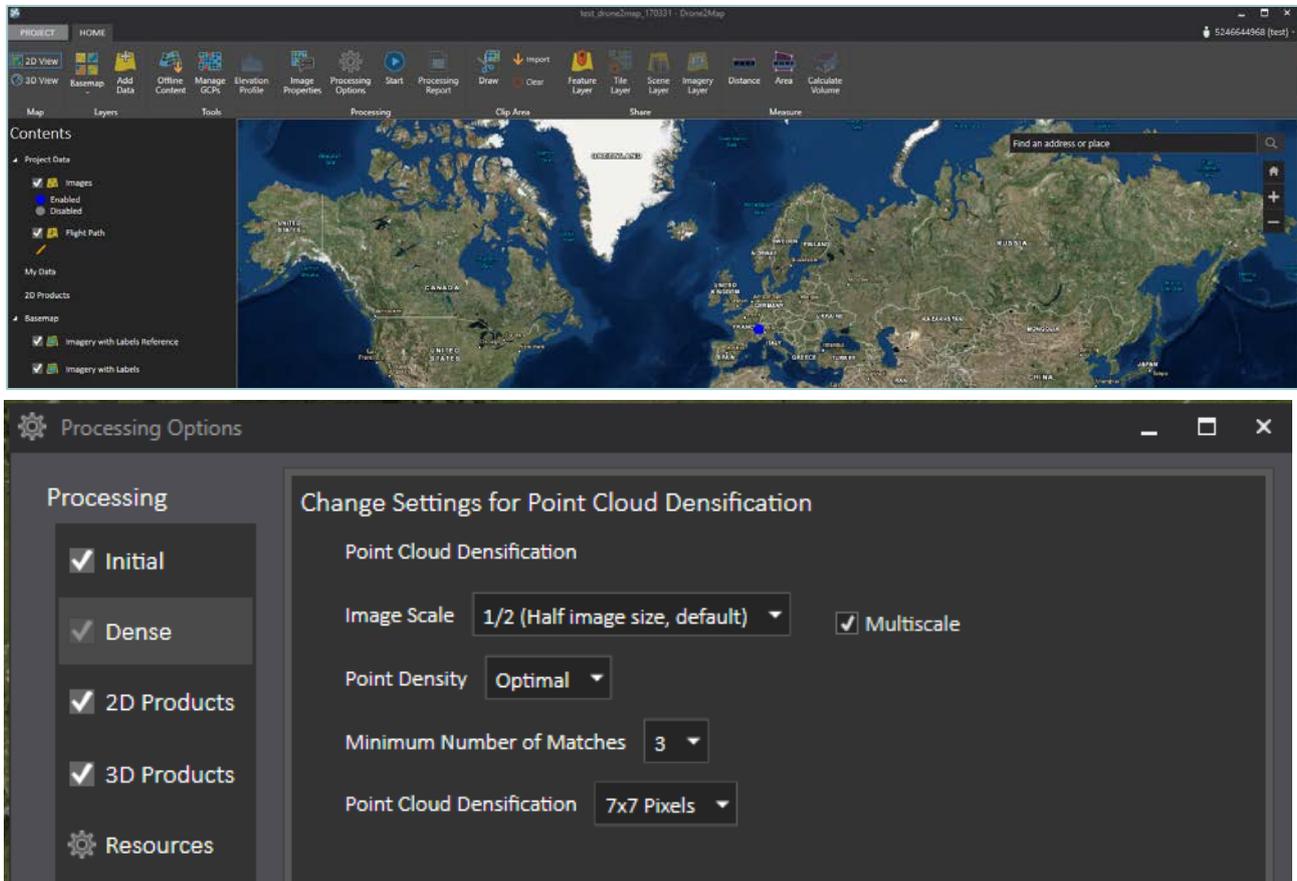
- User-friendly
- Good range of parameters for a non-specialist
- Quick evolution of the software, progress surely to come
- Q/A quite well documented on the website
- Correct quality rendering for mixed ground (vegetation + rocks)

Weak points:

- No Point cloud export allowed if not Pix4D Mapper Pro version
- Mosaic color equilibrium doesn't result in an homogeneous orthophoto
- In Beta version (not the last) the DTM-like process is semi manual: time-consuming, subjective classification, no clean result
- Q/A not very specific for one particular issue
- Poor vegetation precision and rendering

11.2. Drone2Map workflow.

The ESRI software is the most user-friendly. Based on Pix4D, with the same semi-automatic workflow, with even less choice in parameters. Very easy to obtain multiple processed products without knowledge.



Strong points:

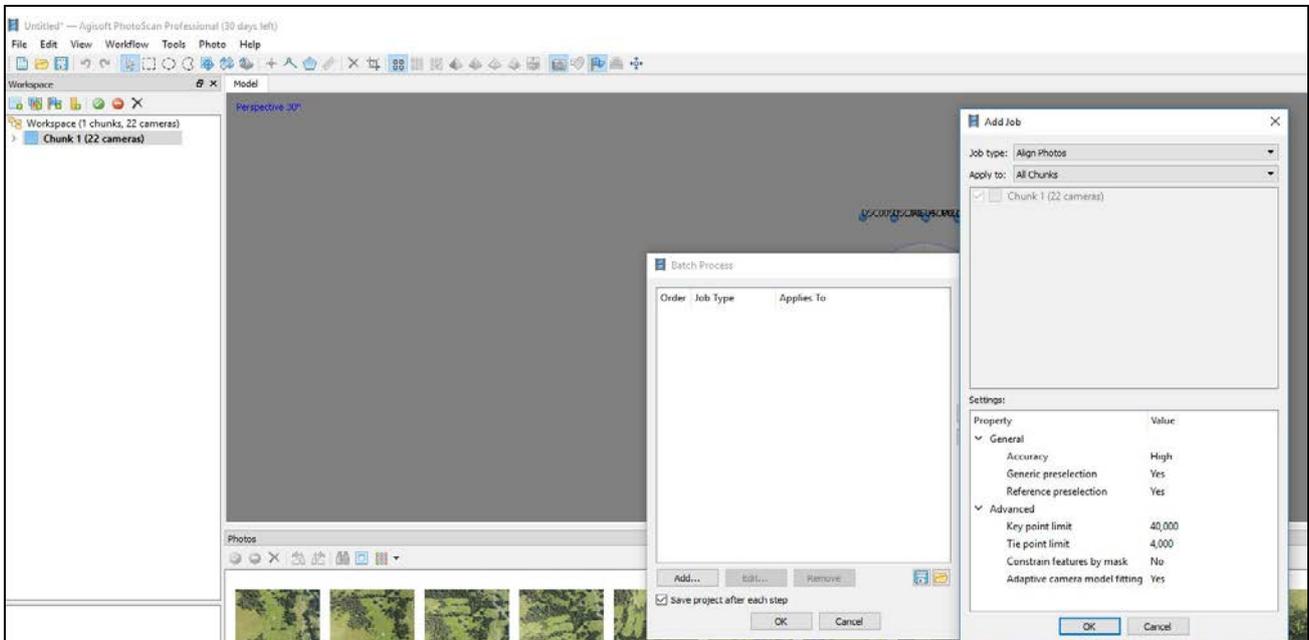
- Very user-friendly for beginners
- Step by step or all at once
- Can save basemap for offline use
- Automatic DTM-like surface

Weak points:

- Installation: Hard to find the setup to download on the website, need to create an account online to activate the license, installation is long and didn't work on the first trial
- No point cloud edition mode
- Few possibilities for parameters
- Need to know your coordinate system parameters to import pictures
- Supposed to be easily add as an extension in ArcGIS but couldn't find how
- Don't really know how the DTM-like surface is created (which criteria?)

11.3. AgiSoft workflow.

At first glance AgiSoft doesn't seem user-friendly, looking like windows 95. But it is offering many possibilities. It can be used as Pix4D or Drone2Map for a "all at once process" but its strength is in the step-by-step process, allowing to modify and correct parameters at each step to obtain the best result.



Strong points:

- Very complete software
- A lot of parameters and many settings for each
- Point cloud edition (points or mask)
- Tutorials and explanations available on official website
- Very dense point cloud
- Intelligent DTM-like process (reference angle discrimination)
- The best with vegetation modelling

Weak points:

- 3D mouse navigation less intuitive than in other software
- So many settings possible, knowledge about what they change is required
- Very dense point cloud, need to reduce it sometimes for lower capacity computer

III. Result comparison.

Computer used for test: DELL, with Windows 10, Intel Core i7, 2.70GHz, 16GB RAM, 64 Bytes model and GPU: Intel(R) HD Graphics 530 (Driver: 20.19.15.4531).

Test parameters		Drone2Map	PIX		Agisoft pro
		Parameter main options			
Initial	image scale	Full/ rapid/ custom (1/8-2)	Full/ rapid/ custom (1/8-2)	Align photo: accuracy medium (1/4)	
	matching image pairs	Aerial rid / free flight/2 neighboring images / triangulation / relative distance between consecutive images / image similarity / use time for multiple cameras	Aerial rid / free flight/2 neighboring images / triangulation / relative distance between consecutive images / image similarity / use time for multiple cameras	advanced: key point limit (40000), Tie point (4000), adaptive camera model fitting	
cloud densification	matching stratégie	geometry verified matching (Y/N)	geometry verified matching (Y/N)		
	image scale	1/8-1 + multiscale (Y/N)	1/8-1 + multiscale (Y/N)		
	Point density	low/ optimal/high	low/ optimal/high		
	Number of matches	2-7	2-7	quality : medium, depth filtering: moderate	
	Point cloud densification	7x7 - 9x9 pixels	7x7 no other choice proposed		
2D products	Orthomosaic resolution	1-100x GSD or cm/px	1-100x GSD or cm/px	10 cm/px / blending mode Mosaic / hole filling	
	DSM	inverse distance / triangulation + noise filtering (Y/N) + surface smoothing (sharp/ medium / smooth)	inverse distance / triangulation + noise filtering (Y/N) + surface smoothing (sharp/ medium / smooth)	DEM : Interpolation (extrapolation possible)/Point classes / projection / resolution 5cm/px	
	DTM	5x GSD ou 5cm/px (by default) / DTM automatique	old version: DTM beta version, manual & time consuming / Now: no more beta version	semi-automatic (create markground points then fix an angle to discriminate if not ground)	
3D products	Point cloud	export as LAS/PLY/XYZ	export as LAS/PLY/XYZ	export as LAS/PLY/XYZ	
	3D textured meshes	Scene layer package/ OBJ /FBX / AutoCAD DXF / PLY /3D PDF logo	OBJ /FBX / AutoCAD DXF / PLY	OBJ /FBX / AutoCAD DXF / PLY	
		6 display settings		Face count: medium/200000	
Nb d'image tester		22	22	22	
Temps d'analyse		23 minutes (DTM compris)	13 minutes	15 minutes	
Densified point cloud		3095100	3090521	18355970	

*Agisoft: Maximum parameters not supported by the computer, so only optimal setting results.

IV. Compatibility options.

Those three softwares offer similar outputs which can be analysed under specific softwares like ArcGIS, QGIS or AutoCAD.

AutoCAD Civil 3D can import point cloud data under LAS format, other vector data (contour lines, AOI) as shapefiles or dxf and raster data (orthomosaic, DSM) as a GeoTiff. Import of point cloud is simple but can be very long.

ArcGIS Desktop is compatible with the same file format: import point cloud data under LAS format, other vector data (contour lines, AOI) as shapefiles or dxf and raster data (orthomosaic, DSM) as a GeoTiff. Though importing a point cloud is more complicated as it necessitates multiple steps like the creation of a LAS dataset, prior to importation.

Using QGIS to compute your drone data, you will need to add a tool to your basic QGIS to compute your point cloud data.

 First install "LAStools" then in the top menu select "Processing" / "option and configuration" to open the "Processing options" window. Then unfold "Providers" to access "Tools for LiDAR data" and activate it and complete the path to the LAStool folder. Then you can select the "lasview tool" to load your point cloud as a LAS or LAZ (compressed). LAS tool under v2.14 of QGIS had some troubles to run sometimes. See if solved in v3.

Then for the other vector data (contour lines, AOI) as shapefiles or dxf and raster data (orthomosaic, DSM) as a GeoTiff like for ArcGI and AutoCAD.

To conclude, as long as you export the point cloud in LAS format (or LAZ then unzip it) it is possible to use the three tools mentioned below: with AutoCAD it is simple but long, with ArGIS more steps but nothing too complex and with QGIS you need to add and configure a plugin. For the other outputs (orthomosaic, DSM, contour lines, etc.) shapefiles, GeoTiff and dxf are compatibles.

V. Licence.

	Drone2Map	PIX4D Mapper Pro	Agisoft pro
<i>Time-limited</i>	yes	yes	no
<i>Cost per year</i>	1500 USD/yr	2600 EUR/yr	3499 USD/yr
<i>Cost per month</i>	x	260e/month	x
<i>Details</i>	1 user	simultaneously 1 desktop + one laptop	1 machine only

Drone2Map for ArcGIS (3)

par Esri

ACHETER

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Tarification : U.S. \$1,500 per user per year. Click the Buy button to begin your purchase. Ensure you are a designated purchaser in ArcGIS Online before proceeding.



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** Support, upgrade & cloud extension (optional), 10% of perpetual license price if purchased while valid, 15% afterwards

Desktop can run on 2 devices simultaneously one desktop and one laptop

For cameras above 55MP, semi-global matching and camera rig add-ons, contact sales@pix4d.com

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VI. Discussion.

The aim of the experiment was to compare the three major commercial software in there ease of use and quality of dense point cloud, orthomosaic and DTM-like rendering.

- According to both results and literature review, AgiSoft Photoscan is the most complete and deliver the best quality results for scientific purpose (density, precision and accuracy), while Pix4D and Drone2Map are more user-friendly and deliver a lower scientific quality product, but still very good for many uses.
- Given the result of the high density point cloud, AgiSoft is obviously recommended for high precision modelling, mostly if the field is partially covered with vegetation.
- No issue is to be reported to import data into GIS or AutoCAD softwares in order to work on a project if data are exported in the most common compatible format (LAS for point cloud, shp/dxf for other vector data and GeoTIFF for raster data).